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F-Canyon Suspension and Deactivation Safety Analysis Reports

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ABSTRACT

This paper describes Savannah River Site's compliance with the Department of Energy (DOE) direction to suspend current operations, transition to accommodate revised facility missions, and initiate operations to deactivate F–Canyon using a suspension and deactivation safety basis. This paper integrates multiple Workshop theme topics – Lessons Learned from the Safety Analysis Process, Improvements in Documenting Hazard and Accident Analysis, and Closure Issues – Decontamination & Decommissioning. The paper describes the process used to develop safety documentation to support suspension and deactivation activities for F-Canyon. Embodied are descriptive efforts that include development of intermediate and final "end states" (e.g., transitional operations), preparation of safety bases documents to support transition, performance of suspension and deactivation activities (e.g. solvent washing, tank/sump flushing, and laboratory waste processing), and downgrade of Safety Class and Safety Significant equipment. The reduction and/or removal of hazards in the facility result in significant risk (frequency times consequence) reduction to the public, site workers, and the environment. Risk reduction then allows the downgrade of safety class and safety significant systems (e.g., ventilation system) and elimination of associated surveillances. The downgrade of safety systems results in significant cost savings.

Introduction

The F–Canyon operated over 45 years and, during that time, the safety basis was addressed in several different types of safety documents which have been revised in both format and content. The original Safety Analysis Report (SAR) and Operational Safety Requirements were based on Department of Energy (DOE) Order 5480.1B. In the early 1990s, the documentation was revised to a Basis for Interim Operation (BIO) per DOE Order 5480.23 and DOE–STD–3011. The BIO was upgraded based on direction from DOE–Savannah River to include more SAR-like information based on DOE–STD–3009. The BIO remained as the main SB document throughout the 1990s based on discussions of limited mission life for F-Canyon. In 2001, DOE issued 10 CFR 830, which directed preparation of DSAs and Technical Safety Requirements (TSRs) for Nuclear Facilities based on DOE–STD–3009. Since the BIO contained much of the information required by DOE–STD–3009, WSRC proposed, and DOE-SR concurred with, a plan to revise the BIOs into graded approach DSAs. One of the more significant parts of that discussion included the preparation of a roadmap that compared DOE-STD-3009 requirements with the contents of the proposed DSA.[1] DOE approved this graded approach DSA in September 2001. During this time, discussions regarding the mission life of F-Canyon continued. Later in 2002, DOE issued a Plutonium Uranium Extraction (PUREX) Suspension Plan.[2] In 2003, DOE approved the F-Canyon Complex Deactivation Project Plan allowing deactivation but not the decommissioning of the F-Canyon complex.[3]

The challenge for this effort was to produce a set of safety documents that would have the flexibility to allow the facility to smoothly transition through the various phases of suspension and eventually deactivation. The set of safety documents included, but was not limited to, a Documented Safety Analysis, Technical Safety Requirements, Justification for Continued Operation, Double Contingency Analysis, and Emergency Preparedness Hazards Analysis. This paper documents how the Integrated Safety Management Process, see Figure 1, was followed during the preparation of these documents.

Defining the Scope

One of the most significant parts of this effort was defining the scope of the work. For the purposes of this paper, the scope is divided into two parts, the project scope defined by the PUREX Suspension Plan and the Deactivation Project Plan. The scope of the safety basis is more explicitly defined by the Safety Basis Strategy Document. These documents are discussed in the following paragraphs.

DOE Order O 430.1B, “Real Property Asset Management,” requires for facility disposition an end-point process in deactivation and decommissioning planning that identifies specific facility end-points and activities needed to achieve those end-points.[7] To support this requirement, DOE has issued DOE/EM-0318, “Facility Deactivation Guide Methods and Practices Handbook,”, that describes acceptable ways of determining end points (i.e., an end point is a specific task that serves to accomplish one or more of the objectives of the deactivation) and DOE-STD-1120, Integration of Environment, Safety, and Health Into Facility Disposition Activities. The Savannah River Site excess facility disposition program uses a graded approach to requirements, whereby, the level of effort and commitment of resources is commensurate with the size and complexity of the facility and the relative importance of the management element to safety.

Currently, transition from operation to deactivation is being accomplished as shown in Figure 2 by implementation of the PUREX Suspension Plan. The Suspension Plan was issued February 28, 2002, and has been approved by DOE-SR. It was later revised to allow limited deactivation to begin on a few systems that had been out of service. The Suspension Plan is the equivalent of a Safe Shutdown Plan per the WSRC 1C Manual. The PUREX operation in both F-Canyon and FB-Line were complete on March 27, 2002.

The F-Canyon Complex Deactivation Project Plan, which will be referred to as the Deactivation Project Plan (DPP), provides the scope of work to be performed to deactivate the F-Canyon Complex (FCC). This includes F-Canyon, FB-Line, and several support facilities. The purpose of deactivation is to reduce risk while providing a smooth transition from operations to a low-cost surveillance and maintenance mode. At the completion of deactivation, the facilities will be in a

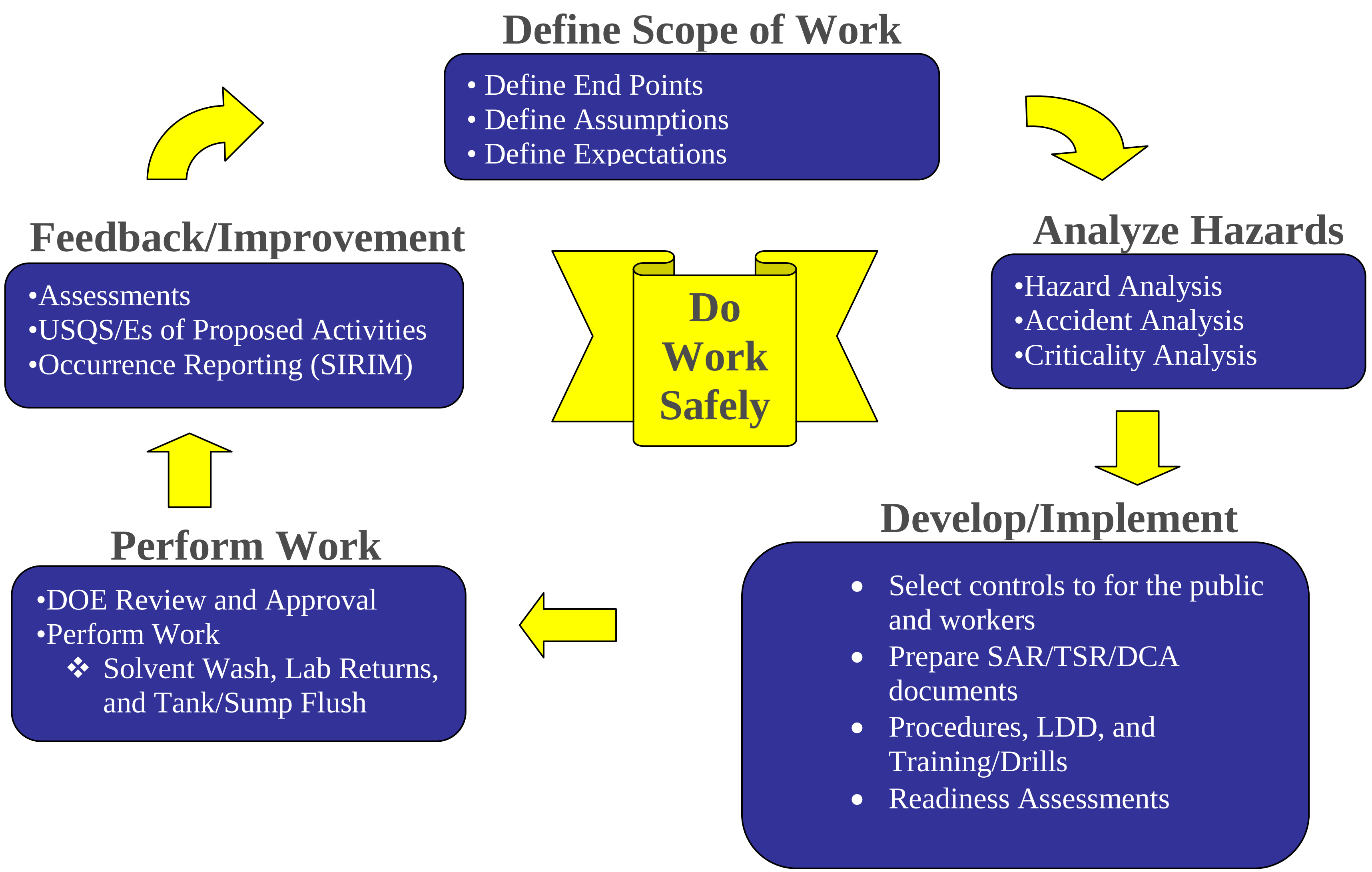

Figure 1 **Safety Documentation Process**

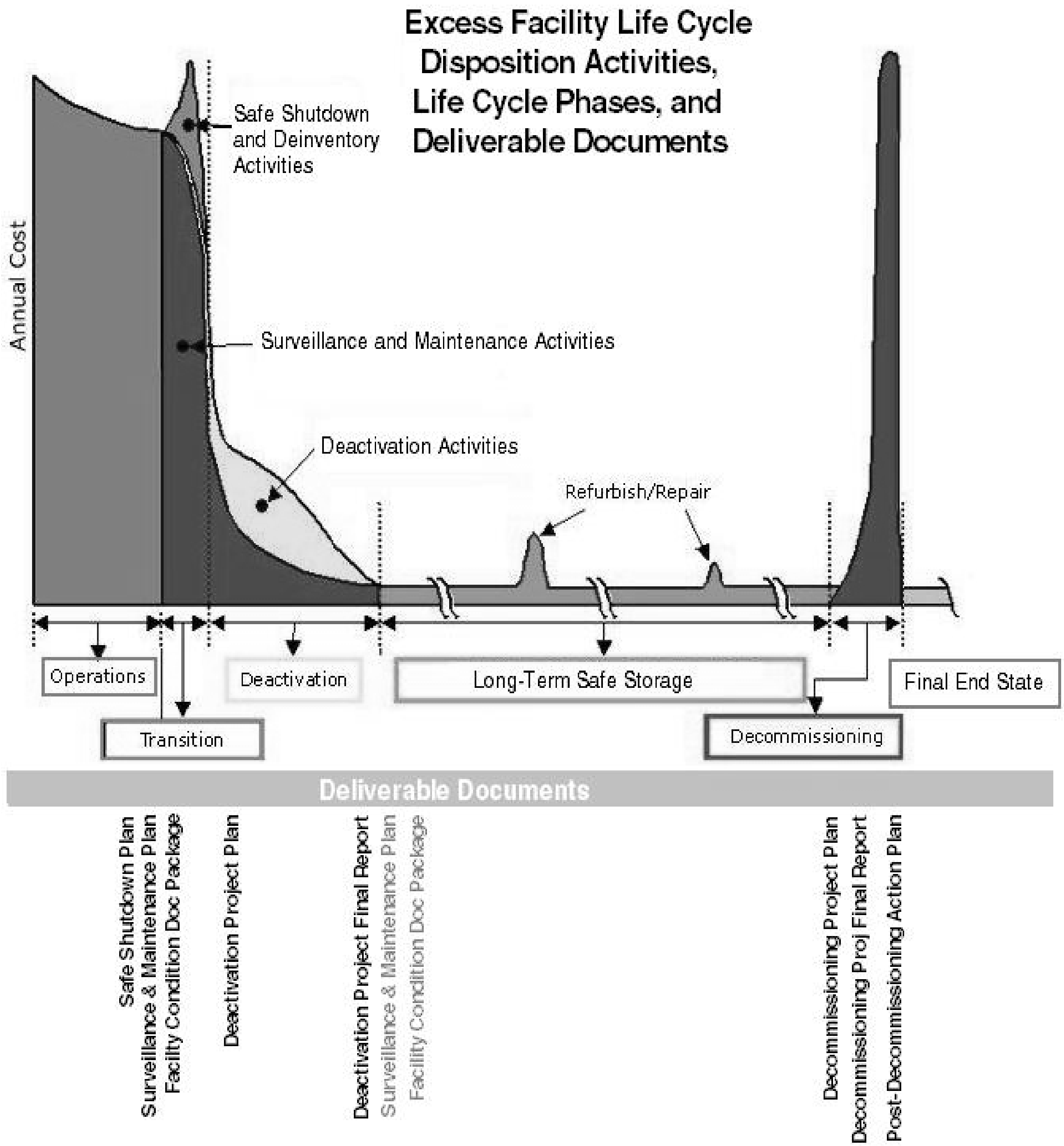

Figure 2 **Excess Facility Life Cycle.**

cold, dark, and dry state. The DPP is a deliverable identified in the WSRC Manual 1C, Facility Disposition Manual. The DPP was issued in 2003 and has been approved by DOE-SR.

FB-Line still has an operations mission, which is to characterize plutonium materials, stabilize them by packaging in 3013 containers, and shipping the materials to another facility onsite. As a result, deactivation activities in F-Canyon will lead those in FB-Line. However, because the facilities are interdependent, FB-Line hazards must be removed before F-Canyon can complete deactivation.

The DPP was prepared with direct support from subject matter experts having deactivation experience at other DOE sites. The DPP development work was accomplished using a systematic technique employed at other DOE sites to specify desired end points. Each facility system and space was assigned a desired end point that was compared to the expected condition at the end of the applicable operating mission. Once this comparison was performed, a series of tasks were identified to deactivate that system or space. The scope of the deactivation effort is defined by these tasks. These tasks were then integrated into a detailed project schedule.

This purpose of a SBS document is to define the baseline scope of work, baseline assumptions, management expectations, costs and schedule, and obtain up-front agreement from all key stakeholders. The SBS documents the use of a graded approach for the development of the SB documents that allow the transition from the post-PUREX AB to the point in time when the site "walks away" from F-Canyon with minimal ventilation running.[3] This graded approach provides clear direction ("step-out" criteria) such that when a hazard has been eliminated, the controls may be eliminated without the need to go back and revise the DSA documentation. In addition, the use of "step-out" criteria has been applied to the Emergency Preparedness Hazards Assessment (EPHA) and Emergency Action Levels (EALs) (i.e., as the hazards decrease, the EALs decrease).

The graded approach documented in the SBS was to start with the existing SB documents and evaluate the activities documented in the Project scope against the existing hazards and/or events documented in the existing DSA. The graded approach also specified a single accident analysis calculation that would use the existing accident analysis with a reduced source term. The EPHA was performed in a similar manner, i.e. use the same accident scenario methodology but with a reduced source term. This approach has the advantage of bounding all major suspension and deactivation activities and providing defined "step-out' criteria.

The scope for the SBS was defined in terms of the current F-Canyon process areas and suspension and deactivation activities. The list of general process areas include: Receiving and Storage, Fuel Decladding and Dissolving, Head End, First Cycle Solvent Extraction, Second Plutonium Cycle Solvent Extraction, Second Uranium Solvent Extraction, Solvent Recovery, Waste Concentration, Laboratory Waste Processing, Rerun, Cold Chemical Operations, Process Support Systems, Outside Facilities and A-Line. General suspension and deactivation activities have been divided into four phases. The four phases include: Product Stabilization (Operations), De-Inventory, Facility Stabilization and Equipment Shutdown/Isolation, and Surveillance and Maintenance and Material Management. More detail of the work within each phase is provided later in this paper under the "Work Performance" section. Finally, because F-Canyon supports other facilities, the scope of suspension and deactivation included impacts to other facilities.

Hazard Identification and Control Selection

The current F-Canyon DSA has a comprehensive hazards analysis based on full facility operations. The hazards analysis needed to be revised to support a facility going through suspension and deactivation. A task team with representatives from Operations, Engineering, Regulatory Programs, safety analysis, and criticality safety was assembled to review the hazards analysis and determine: 1) the applicability of existing hazard scenarios with respect to suspension and deactivation activities and 2) the potential for creating significant new hazard scenarios.

Each processing area was evaluated by addressing the following five defined, descriptive hazard criteria:

1. No longer applies because the hazard has been removed as part of suspension.
   - Flushing processing vessels in each operational area to residual quantities of hazardous (radioactive and/or chemical) material.
   - Removing solvent from various vessels and isolating it in several canyon tanks.
2. Although not completely eliminated, the hazard has been significantly reduced due to suspension.
   - Sampling processing vessels to verify that only residual quantities remain in the vessels.
3. Suspension will eliminate the source of the hazard, but the hazard may still exist due to previous processing.
   - Sampling processing vessels to verify that only residual quantities remain in the vessels.
4. Still applies, these types of activities will continue during suspension.[11]
5. New hazard scenario created for based on suspension or desired end state condition.

As part of the hazard identification process, the team also evaluated what, if any, controls were necessary for the hazards that remained. To facilitate the control selection process, an engineering calculation was performed to estimate the consequences associated with suspended operations and a “residual” source term. The calculation conservatively assumed that 450 grams of plutonium remained in each process vessel and was available for release. In effect, the engineering calculation provides well defined “step out” criteria for tanks and processes. The results of the calculations showed that the consequences for most accident events are below both the offsite and onsite evaluation guidelines; and therefore, the accident events do not warrant Safety Class (SC) or Safety Significant (SS) controls. A “before and after” comparison of F-Canyon risks are depicted in Figures 3 and 4. As Operations personnel flushed the process vessels and gathered sample data, a second engineering calculation was performed that demonstrated that the amount of plutonium available for release was actually about 5 grams.

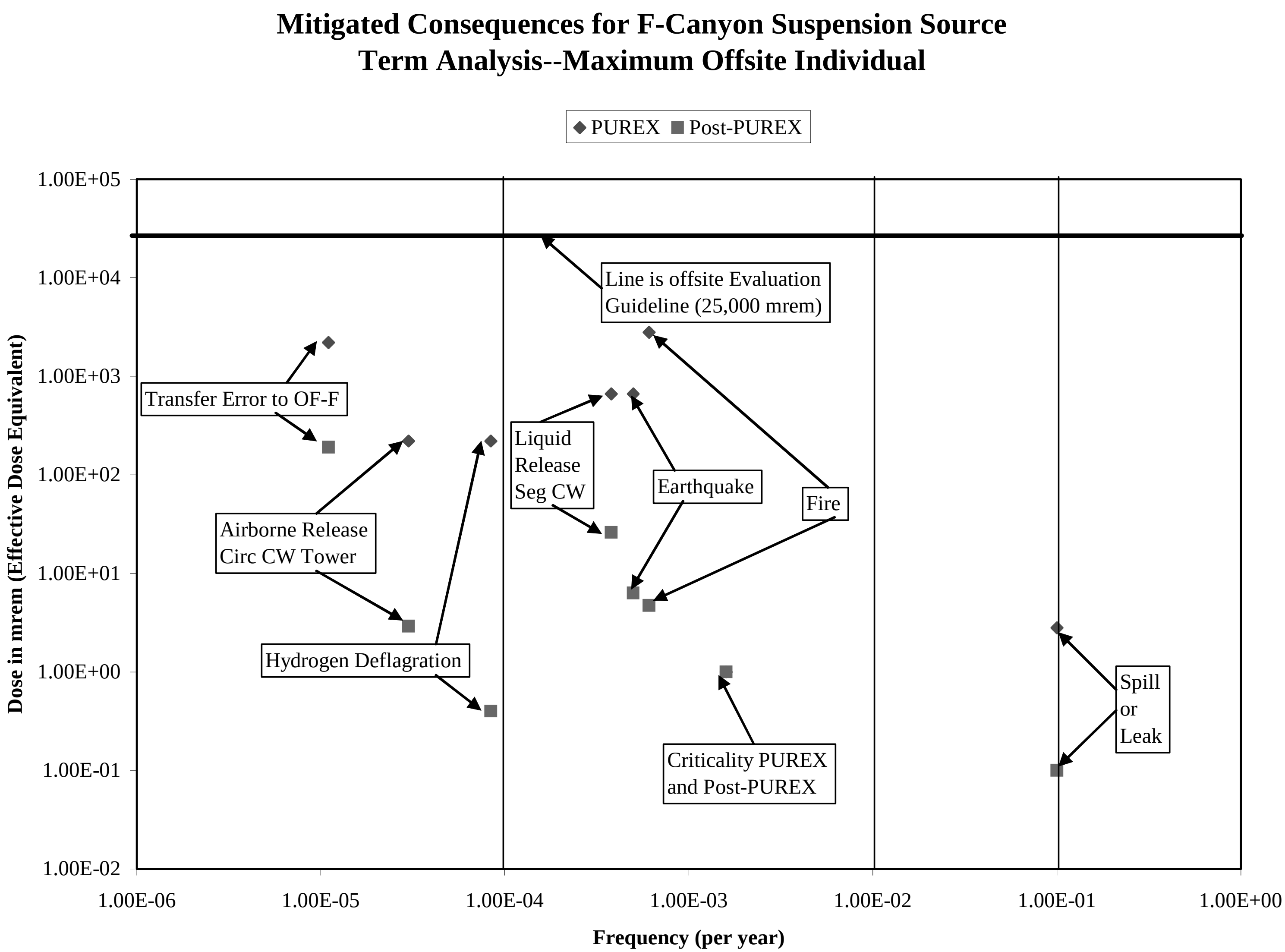

Figure 3 **Reduced Offsite Consequences for F-Canyon Suspension Source Term**

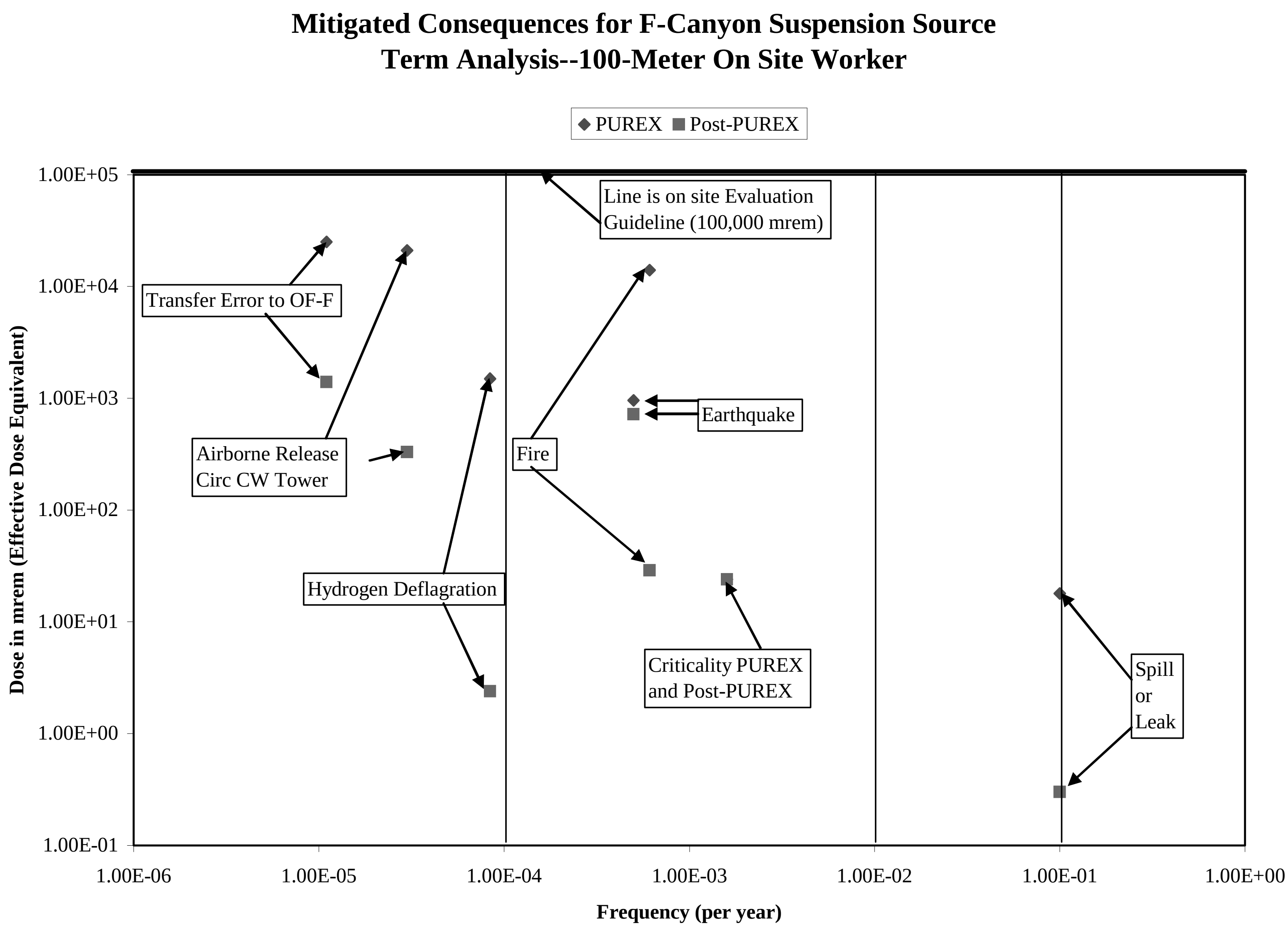

Figure 4 **Reduced On Site Consequences for F-Canyon Suspension Source Term**

In the TSR, residual was defined as material remaining in a PROCESS AREA such that: (1) the dose contribution to the event consequences evaluated in the accident analysis is negligible; (2) the hydrogen generation potential of the remaining material is insignificant; (3) the quantity of fissile material contained within the PROCESS AREA is less than that required to form a critical mass and configuration; and (4) the material contains insufficient solvent to pose a fire hazard. These quantities will be determined by Engineering.

To comply with the TSR definition, an engineering evaluation[12] identified the following as meeting the definition of residual:

1. A vessel (tank) shall contain no more than 5 grams of plutonium.
2. Processing vessels (tanks) are to be emptied to heel.
3. Solvent is to be removed from any vessel that contained liquid organic material.
4. Dissolver – At least one port cover and that port's insert are removed, or the equivalent in jumpers are to be opened to the atmosphere. Limits 1 and 2 are met.
5. Evaporator – At least one jumper (or 3 inch diameter equivalent piping) connection opened to the atmosphere and drained to heel. Limit 1 is met.
6. Am/Cm processing vessels are to be diluted so that the remaining solution contains no more than 20 curies and the vessels (tanks) are emptied to heel.
7. Vessels (tanks) are to be configured (e.g., process blanks installed, transfer jumpers removed, and double valve isolation) such that the volume of material will not increase above heel due to leaks, and transfers into the vessel (tank) are not possible.[13]

At this time, the canyon exhaust system (building, exhaust tunnel, exhaust fans, diesel generators, and sand filter) remains functionally classified as SC and will continue to remain in place. Future work will include an evaluation of consequences without credit for the canyon exhaust system to determine if this equipment may be downgraded.

Develop and Implement Controls

The F-Canyon Suspension DSA was prepared and contains two accident analyses, one for operations and the other for suspension and some deactivation activities. The accident analysis for operations was determined to be sufficient to cover Product Stabilization and De-Inventory Activities. The accident analysis for suspension and deactivation activities was determined to be sufficient to cover Facility Stabilization and Equipment Shutdown/Isolation activities. The use of two analyses and "step-out" criteria allowed facility personnel to maintain the state of operational readiness required, yet continue to transition from phase to phase with minimum impact to the safety basis.[14]

Understanding what controls could be eliminated along with associated surveillances and maintenance simplified the actual number of implemented controls. For example, as a tank is flushed to support eventual deactivation, identified "step-out" criteria specifies what controls can be relaxed (e.g., TSR surveillances are no longer applicable since the tank is "out of service" or criticality scenarios are eliminated with reduction/removal of fissile material) without requiring a revision to the current SB documents.

Double Contingency Analysis – Credible and Incredible Scenarios

The DCA is the product of an expert-based review process that considers both credible and incredible criticality scenarios, as well as controls required for the credible scenarios. The credible scenarios and identified controls, as well as the incredible scenarios with justification for incredibility are documented in the DCA. As the radioactive material is reduced, the potential for a criticality is also reduced and will be reflected in revised SB documentation.

Performance of Work

The following is a summary of the work that has been completed or is in progress using the DSA and TSRs prepared for F-Canyon suspension and deactivation activities.

Work Activities:

The work was divided into four distinct phases. These phases are: (1) Product Stabilization, (2) De-Inventory, (3) Facility Stabilization and Equipment Shutdown/Isolation, and (4) S&M and Material Management.

Phase 1 – Product Stabilization

- Complete dissolution and disposition of scheduled materials –Rocky Flats Scrub Alloy and MK 42 Compacts.
- Disposition sand, slag, and crucible from depletion of plutonium inventory generated in FB-Line from F-Canyon inventories.
- Evaluate SB documents for required revision.

Phase 2 - De-Inventory

- Reduce plutonium inventory from vessels in F-Canyon and FB-Line to discardable plutonium levels by inventory conversion to metal and/or discard to the Tank Farm.

At the end of this Phase (March 30, 2002), F-Canyon and the FB-Line PUREX processes were in a suspended state (i.e., Warm Standby). The facility was capable of immediate restart**. *PUREX suspension was achieved. F–Canyon is currently in Phase 3.***

Phase 3 – Facility Stabilization and Equipment Shutdown/Isolation

- Discard of plutonium solutions to the Tank Farm (ongoing).
- Flush all vessels identified as key plutonium vessels that normally contain $\geq$ 450 grams of plutonium (ongoing).

- Consolidate Depleted Uranium (DU) solutions in pre-selected F–Canyon vessels per approved Suspension planning (complete).
- Remove solvent from First and Second Plutonium Cycles and de-contaminate to the maximum extent possible (i.e., washing) (complete).
- Remove cold chemicals throughout processing areas that are no longer needed (complete).
- Shutdown PUREX equipment, suspend Preventive Maintenance, and cease required surveillances, where appropriate (ongoing).
- Discard Americium/Curium (Am/Cm) solution to the Tank Farm (complete).
- Cease plutonium accountability (i.e., Safeguards and Security inventory tracking) for PUREX solutions (ongoing).
- Reduce, if possible, the frequency of DU and UO_3 oxide accountability (complete).
- Isolate equipment/piping, as necessary (ongoing).
- Send SRTC and CLAB sample returns to H-Canyon (complete).
- Initiate major review/changes to the SB documents (ongoing).
- Initiate operational staffing reductions (ongoing).
- Unreviewed Safety Question (USQ) process can be used to evaluate flushing activities and no SB changes required (ongoing).

At the end of this phase, F-Canyon and FB-Line PUREX processes are in a Cold Standby mode with reduced costs not capable of immediate restart. Restart is no longer anticipated.

Phase 4 - Surveillance and Maintenance and Material Management

- Implement S&M program for DU solutions, process solvents, and any remaining solutions stored in F-Canyon awaiting disposition.
- Complete revision of SB documentation to allow reduction in SB requirements per DOE–STD–1120.
- Continue to operate equipment required to maintain F-Canyon/Outside Facilities and FB-Line in a safe and environmentally sound configuration.
- Provide limited support for planning of deactivation activities.
- Complete PUREX staffing reductions.[15]

Feedback and Improvement

Feedback and Improvement involves two parts. The first part involves the facility and the work being performed. The second part involves lessons learned from preparation of the SB documents. Feedback to the facility is normally provided through several site programs. These programs include: periodic assessments program, the USQ program, Problem Identification Reports, and, if an event should occur, the Site Item Reportability & Issue Management (SIRIM)

Program. Through these programs, feedback is provided on both individual task-related issues as well as more general facility issues.

The primary feedback and improvement process for the SB documents is the review process. This consists of internal reviews by WSMS and WSRC personnel as well as external review by DOE personnel. Document reviews generally take place later in the development process after significant time and effort have been expended. The SBS document, that was discussed earlier, represents an opportunity to provide feedback early in the SB development process. By providing information related to scope, baseline assumptions, and management expectations at the beginning of the process, the reviews near the end of the process have fewer, less significant comments.

Based on Lessons Learned from the F-Canyon Suspension DSA and TSRs, WSRC plans to issue an F-Canyon Deactivation DSA and TSRs. The differences between the two documents are relatively small. As previously stated, the suspension DSA and TSRs contained two sets of analyses and controls, one for operation and one for suspension. The deactivation DSA and TSRs will contains only those the controls required for suspension and deactivation. The controls for deactivation consist of the building structure and site programs (Radiation/Contamination Control, Industrial Safety, Fire Protection, Waste Management, etc.). Controls for the F-Canyon Exhaust System are being transferred to FB-Line because the exhaust system is no longer required for canyon suspension and deactivation activities.

Future work will consider segmentation of the F-Canyon to determine if the Hazard Class of the facility may be reduced.

Conclusions

The first and most important benefit of this work is the reduction in risk to the public, the worker, and the environment. With the removal of solvent from the facility, accidents such as a red oil explosion or a large solvent fire are no longer credible. In addition, both radiological and chemical source terms have been reduced. Based on reduced source terms, the consequences of several remaining accidents have been reduced by a factor of 100. Because the risk has been reduced, the number of engineered and administrative controls has been reduced and thus the costs associated with maintaining F-Canyon have been reduced.

The safety basis documents were produced in a cost effective manner using the following tools and techniques. First, a Safety Basis Strategy document was prepared to define the scope early in the DSA/TSR development process and obtain agreement from key stakeholders. Second, as a graded approach, the existing hazards analysis was evaluated and used to bound suspension and deactivation activities. Third, also as a graded approach, a simplified accident analyses using the same methodology and reduced source terms was used to justify reduced consequences/risk. And fourth, the use of well defined step-out criteria allowed the facility to step-out of controls and smoothly transition from operations to suspension and deactivation activities.

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